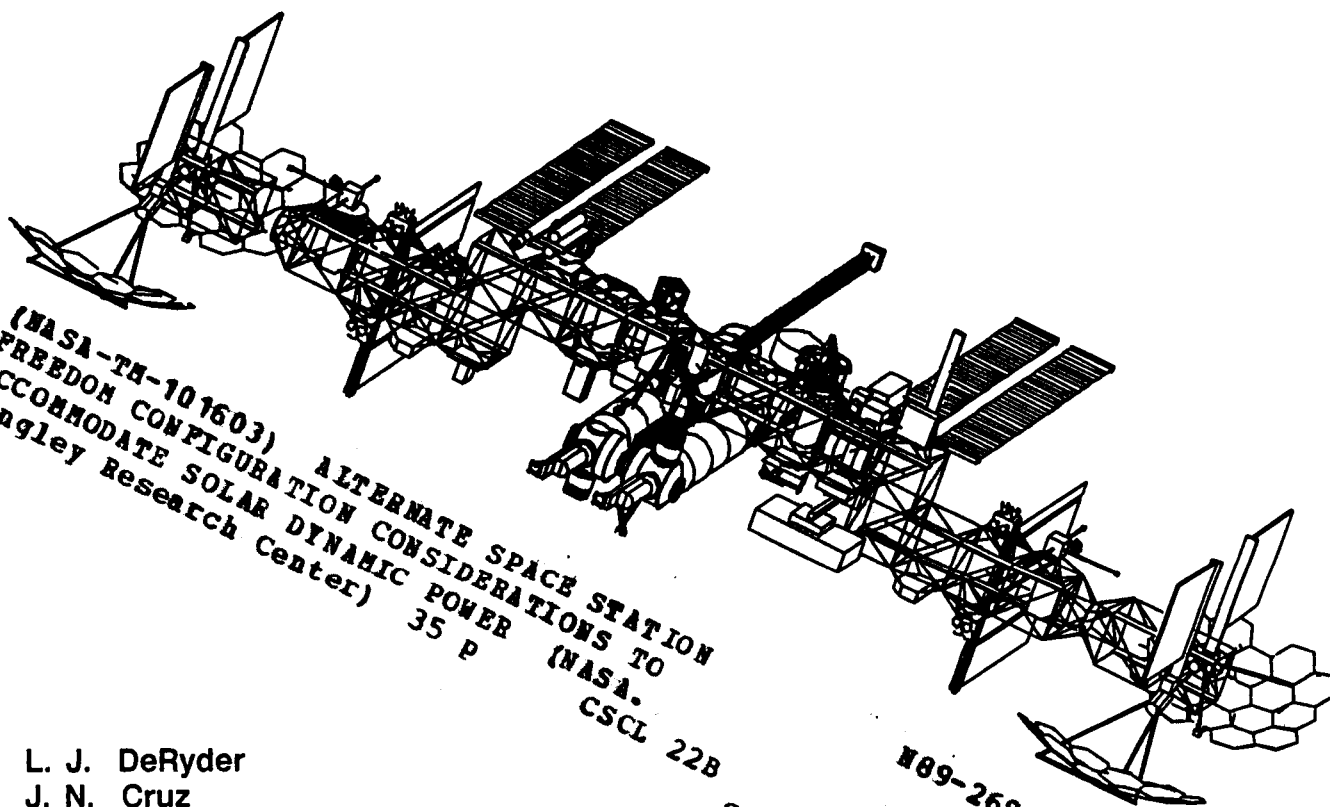


ALTERNATE SPACE STATION FREEDOM CONFIGURATION CONSIDERATIONS TO ACCOMMODATE SOLAR DYNAMIC POWER



(NASA-TM-101603) ALTERNATE SPACE STATION
FREEDOM CONFIGURATION CONSIDERATIONS TO
ACCOMMODATE SOLAR DYNAMIC POWER (NASA-
Langley Research Center) 35 p CSCL 22B

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May 28, 1989

INTRODUCTION

The results of a technical audit of the Space Station Freedom Program conducted by the Program Director was announced in early 1989 and included a proposal to use solar dynamic power generation systems to provide primary electrical energy for orbital flight operations rather than photovoltaic solar array systems. To generate the current program baseline power of 75 kw, two or more solar concentrators approximately 50 feet in diameter would be required to replace four pairs of solar arrays whose rectangular blanket size is approximately 200 feet by 30 feet. The photovoltaic power system concept uses solar arrays to generate electricity that is stored in nickel-hydrogen batteries. The proposed concept uses the solar concentrator dishes to reflect and focus the Sun's energy to heat helium-xenon gas to drive electricity generating turbines. Circulation of the gas through eutectic LiF-CaF₂ salt beds stores thermal energy to operate the turbines when the station's orbital trajectory is occulted from the sunlight. In addition to an overall increase in solar to electric energy conversion efficiency, the primary advantage of the solar dynamic power system concept over the photovoltaic power system concept is the reduced life cycle cost of blanket cell maintenance and battery replacement. A second key advantage is reduced aerodynamic drag area which is a major flight dynamic control system driver.

The purpose of this report is to consider the station configuration issues for incorporation of solar dynamic power system components. Key flight dynamic configuration geometry issues are addressed and an assembly sequence scenario is developed.

ISSUES

Three main issues are addressed related to replacing the present photovoltaic (PV) power system with a solar dynamic (SD) power system concept. The first issue addresses the fact that the current Freedom configuration has flight dynamic characteristics that define a generally unstable vehicle for which special attention must be considered when replacing PV units with SD units. Aerodynamic drag area asymmetry and mass imbalance features must not be increased that worsen the existing unstable vehicle characteristics. The second issue is the reduction of the effects of the large projected drag area, which, as currently configured, results in a large center of pressure (CP) offset from the center of gravity (CG) which requires continuous vehicle attitude rate adjustments to prevent secular angular momentum accumulation. The third issue addressed is related to the assembly sequence approach for which balanced flight geometry configuration stages must be maintained to minimize orbital aerodynamic drag and attitude control momentum management dynamics. A simplified gravity gradient flight mode concept is developed for the initial assembly flights.

ISSUES

- **SOLAR DYNAMIC UNIT INCORPORATION REQUIRES SPECIAL CONSIDERATIONS**
 - CURRENT TRANSVERSE BOOM FLIGHT CONFIGURATION IS GENERICALLY UNSTABLE
 - SD UNITS ADD AREA ASYMMETRY AND MASS IMBALANCE SENSITIVITY
- **LARGE ARTICULATING PV SOLAR ARRAYS DRIVE VEHICLE CONTROL AND REBOOST**
 - HIGH AERODYNAMIC DRAG AREA
 - LARGE 3.5 METER CG / CP OFFSET
 - CONTINUOUS ATTITUDE RATE ADJUSTMENTS REQUIRED FOR ANGULAR MOMENTUM CONTROL
- **ALTERNATE CONSIDERATION AND ASSEMBLY SEQUENCE CONSIDERATIONS**
 - BALANCED FLIGHT CONFIGURATION GEOMETRY
 - LOWER DRAG AND LOWER ORBITAL DECAY RATES
 - LOWER MOMENTUM MANAGEMENT DYNAMICS
 - SIMPLIFIED INITIAL ASSEMBLY FLIGHTS

ASSEMBLY SEQUENCE COMPARISON

The current program assembly sequence is derived from the findings of the 1986 Critical Evaluation Task Force (CETF). Due to revised weight definitions of station elements, reduced Shuttle performance, and other on-orbit utilization and outfitting requirements mandated by program management, the number of Shuttle flights remains under revision, however, the major events leading to assembly completion and evolution definition remain focused.

CETF defined a permanently manned configuration to occur as soon after the establishment of a man-tended configuration as possible, but to occur before the construction of the upper and lower keel truss structure. The permanent manned configuration was established as the program assembly complete definition in this so called "transverse boom" geometry in 1987 as part of a program cost reduction exercise. The solar dynamic power units were phased to be part of the evolution definition along with the upper and lower keel truss structure.

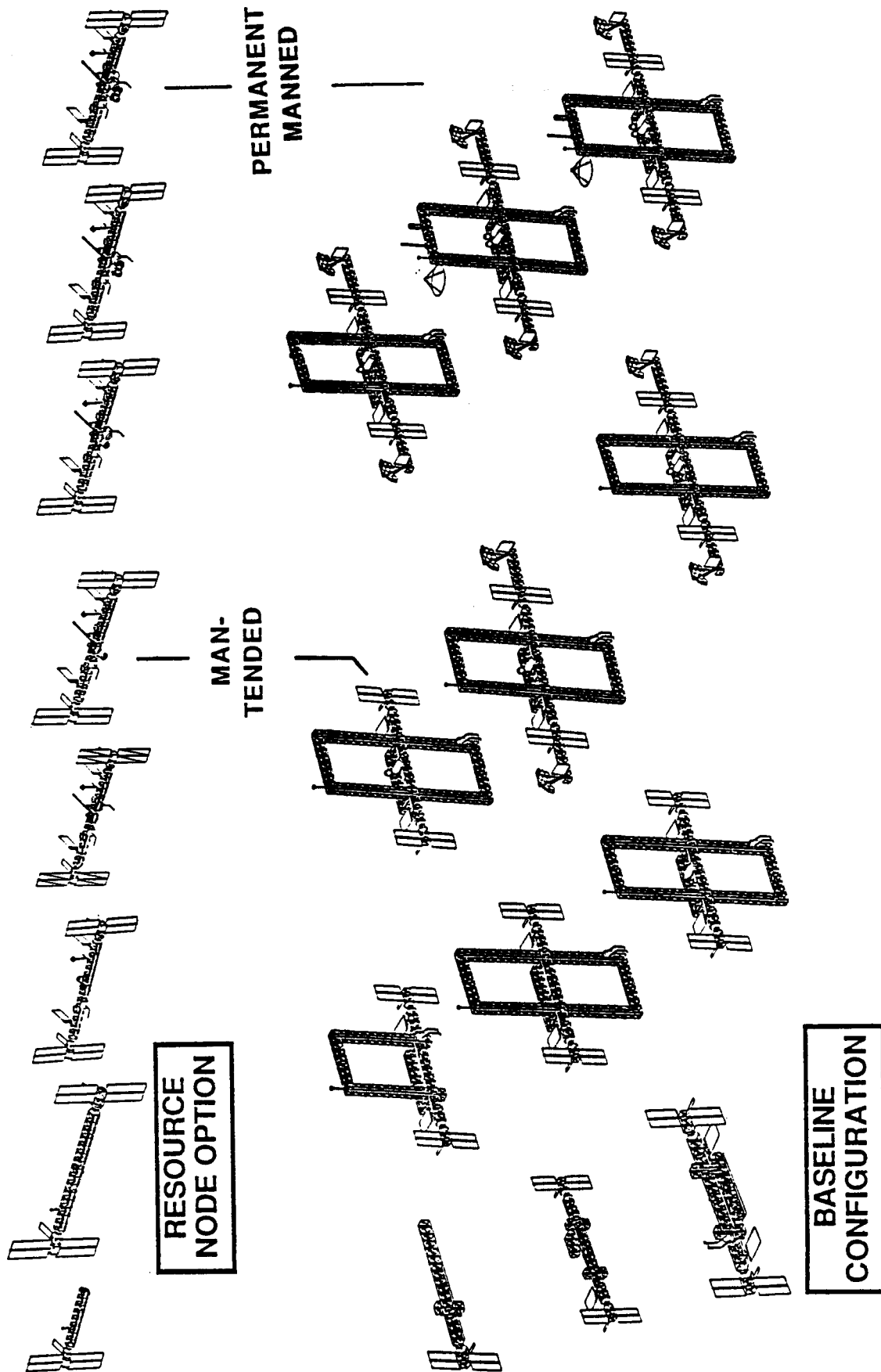
During the CETF assembly definition it was established that the addition of power, in the form of the solar dynamic power system concept, was to be accomplished prior to construction of the keel structure.

The addition of solar dynamic units on the transverse boom in conjunction with the large articulating photovoltaic array blanket area was seen to cause unique flight control concerns due to aerodynamic drag area asymmetry and mass imbalance sensitivities. The addition of the upper and lower keels before the addition of the solar dynamic units was seen to offer gravity gradient pitch axis stability to reduce these sensitivities to solar dynamic area and mass imbalance. However, these issues were not addressed any further due to the program decision to delay the incorporation of both the solar dynamic power units and the upper and lower keels. These were considered to be issues to be addressed as part of the evolution definition.

The technical audit proposal is to add the solar dynamic units on the transverse boom without the benefit of the inherent stability characteristics offered by the upper and lower keels.

Critical Evaluation Task Force

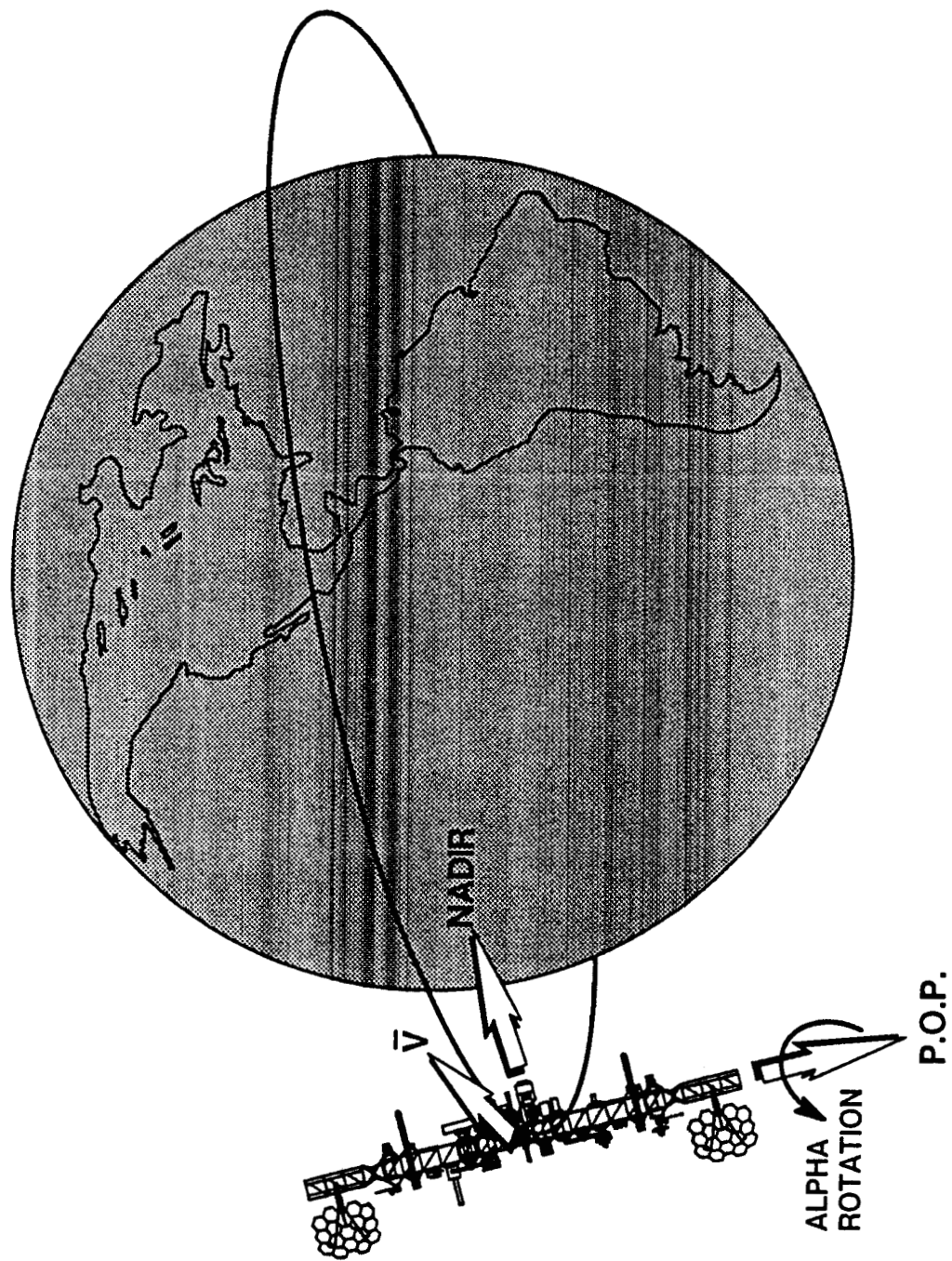
ASSEMBLY SEQUENCE COMPARISON



SPACE STATION FLIGHT MODE

Except possibly for some early assembly flights, the Space Station Freedom transverse boom configuration is defined to have a flight attitude orientation which aligns the length of the truss structure perpendicular to the orbit plane in a constant Earth relative attitude. Inhabited pressurized modules hang below the nadir side of the truss aligned longitudinally along the velocity vector. This geometry results in optimal payload viewing considerations, solar power geometry, and maintains a more constant microgravity sensed acceleration direction. The solar dynamic dishes can rotate continuously about the alpha axis to account for the orbital motion, and rotate about the beta axis to account for solar beta angle geometry.

SPACE STATION FLIGHT MODE



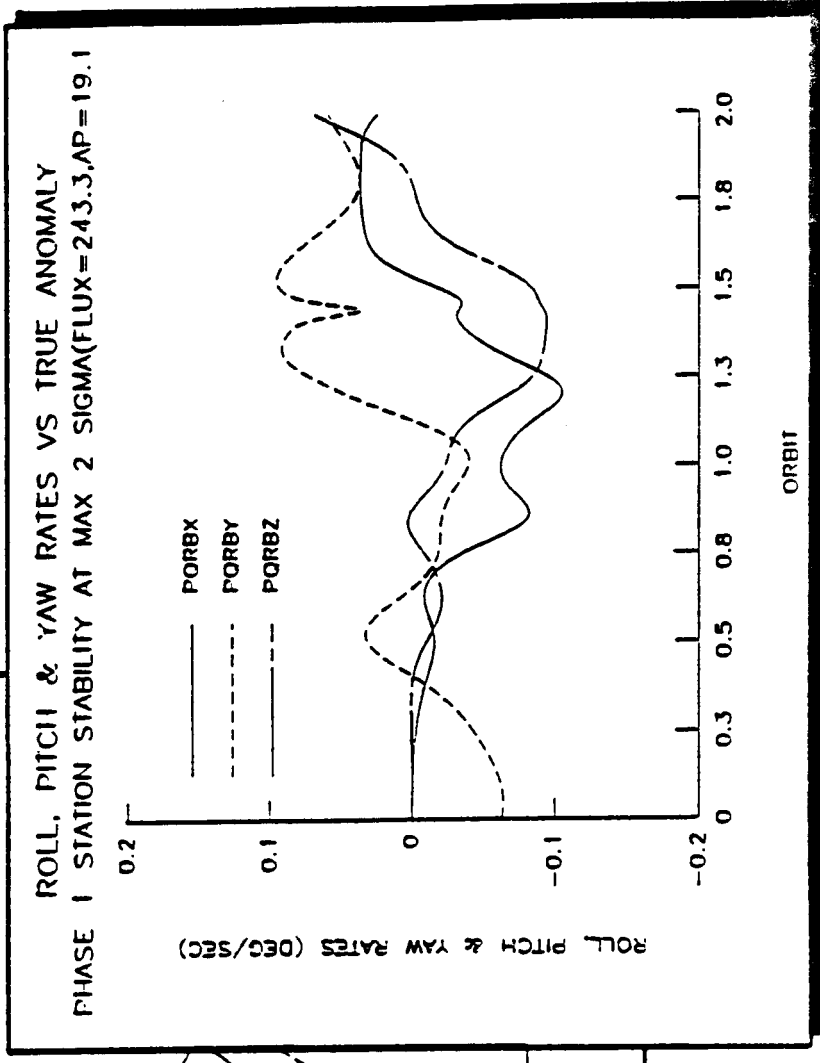
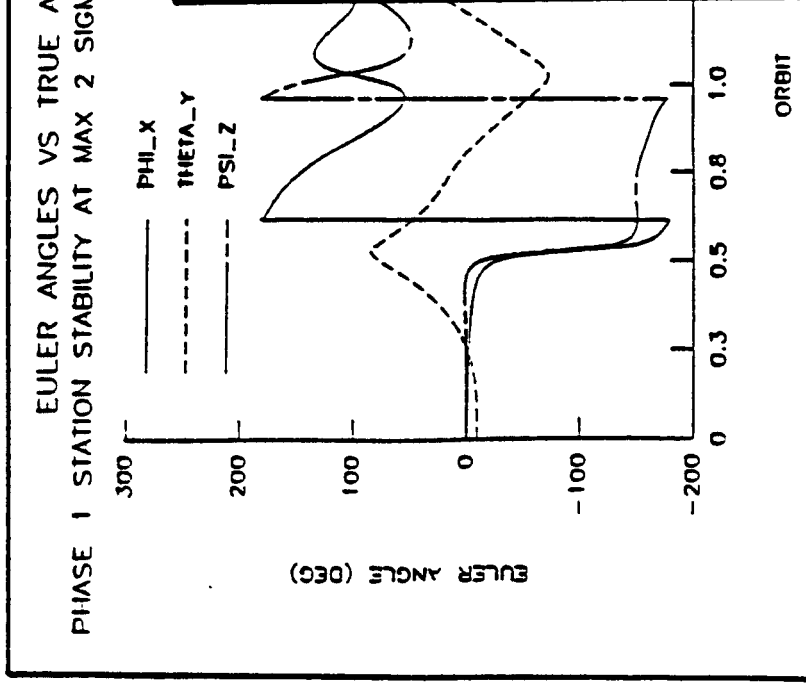
FREEDOM UNCONTROLLED STABILITY CHARACTERISTICS

The flight mode orientation described, with the truss aligned perpendicular to the orbit plane, does not exhibit passive stability characteristics. In other words, the configuration will not remain at the prescribed orientation, and requires active control to maintain the attitude. Control Moment Gyroscopes (CMG's) are currently defined as the Space Station Freedom primary attitude control devices.

The angular momentum management scheme to be implemented in the onboard attitude control system must recognize the generic uncontrolled stability characteristics of the current Freedom configuration definition. The left plot illustrates the attitude time history of the space station in terms of the ordered Euler angle sequence psi, theta, and phi about the yaw, pitch and roll axes respectively. As can be seen, within less than one orbit, all three angles begin to deviate significantly from the initial nominal attitude. A similar phenomenon is shown in the plot on the right which shows the attitude rate time history for the identical simulation. As can be seen, initially pitch, and eventually the coupled yaw and roll channels exhibit attitude rate errors on the order of 0.1 degrees/sec in the absence of active onboard attitude control. These characteristics indicate that continuous active control must be the primary consideration on the attitude control system design definition.

FREEDOM UNCONTROLLED STABILITY CHARACTERISTICS

- PASSIVELY UNSTABLE STABILITY CHARACTERISTICS
 - CURRENT ASSEMBLY STAGE CONSIDERATIONS REQUIRE ACTIVE CONTROL
 - ANGULAR MOMENTUM CONTROL VIA CONTROL MOMENT GYROS



FLIGHT MODE CONTROLLABILITY/STABILITY

The attitude of the space station results in a principal axis orientation such that the minimum moment of inertia pitch axis is perpendicular to the orbit plane. Gravity gradient stable configurations generally require the minimum moment of inertia axis to be aligned along the gravity vector direction (in this case, along nadir). In addition, the nearly equal roll and yaw axis inertias generate little gravity gradient torque about the pitch axis needed to offset aerodynamically induced torques.

An attitude with the minimum moment of inertia perpendicular to the orbit plane is thus generically unstable.

FLIGHT MODE CONTROLLABILITY/STABILITY

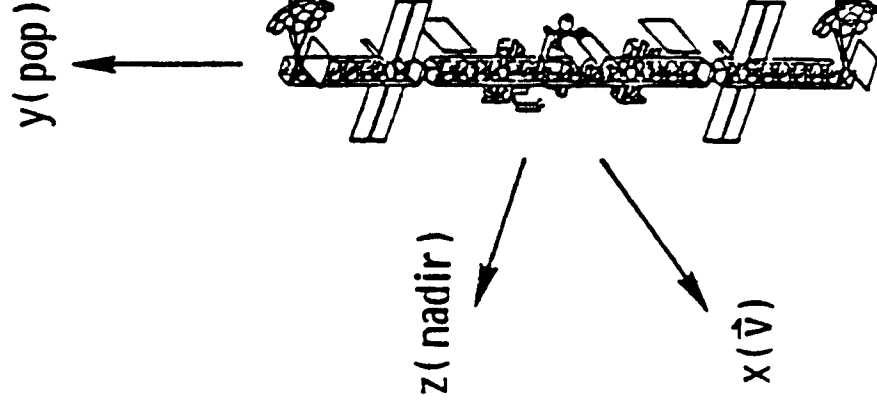
A generic concern

- All PMC options are y_{pop} configurations where:

$$\left[I_{xx}(\text{roll}) = I_{zz}(\text{yaw}) \right] > I_{yy}(\text{pitch})$$

- Little to no gravity gradient pitch stability

Generically unstable equilibrium
flight mode orientation

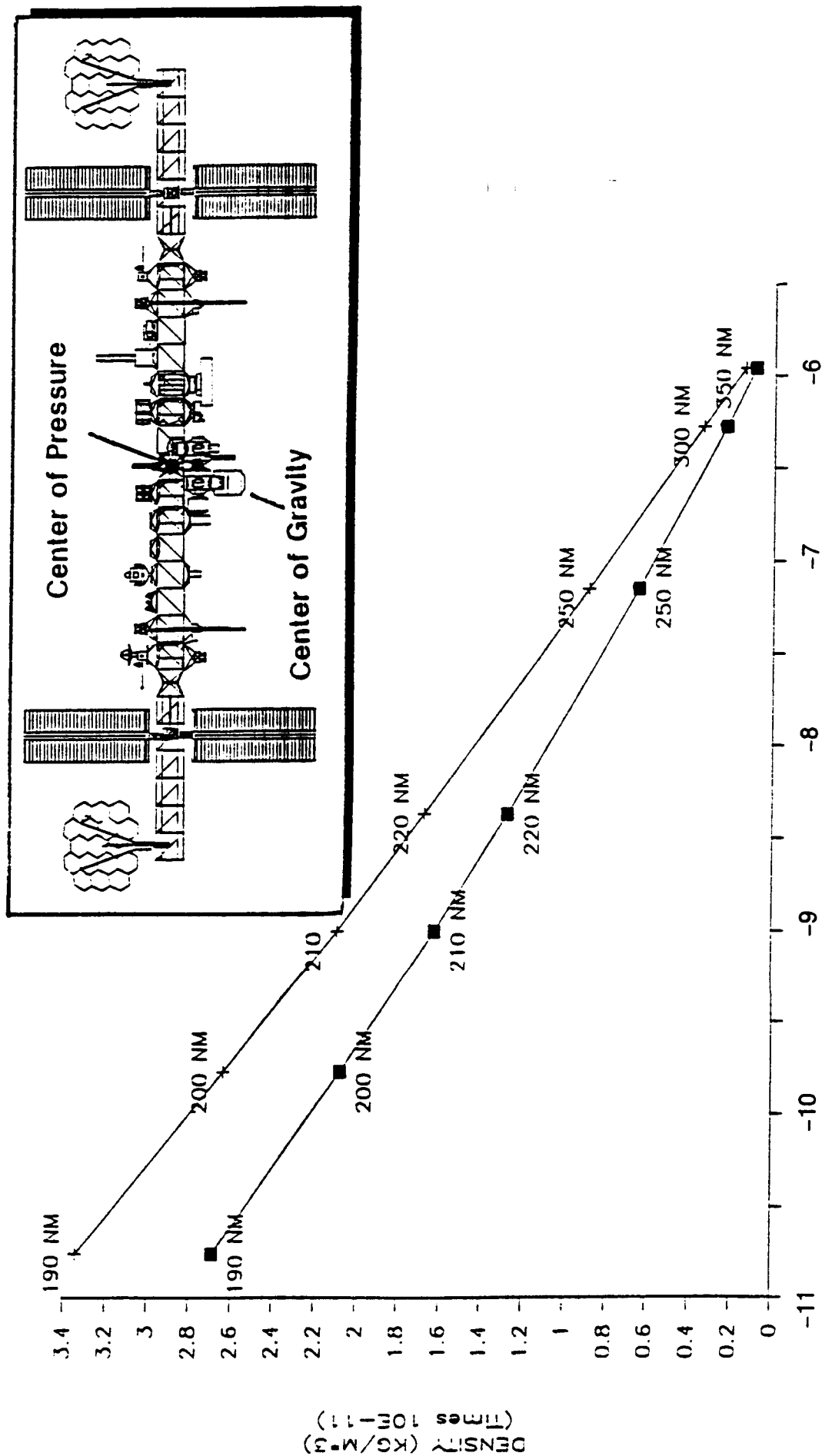


SPACE STATION PITCH TEA vs DENSITY

Because the center of pressure of the current Space Station Freedom configuration lies above the composite center of gravity, aerodynamic forces acting on the station give rise to a pitch torque about the positive Y-axis. The denser the atmosphere, the larger the aero torque. The plot illustrates the torque equilibrium attitude (TEA) about the pitch axis, that is, the attitude at which the gravity gradient pitch torque approximately cancels out the average aerodynamic pitch torque over an orbit. A relatively large negative pitch attitude is required in order to generate an offsetting pitch gravity gradient torque. As can be seen in the plot, the pitch attitude varies from -11 degrees at 190 Nm altitude, to -6 degrees above 350 Nm altitude. The minus 6 degree attitude is a theoretical limit which corresponds to the principal to body y-axis offset for this configuration. In other words, even in the absence of aerodynamics, this configuration would orient the pitch attitude to minus 6 degrees. A configuration mass change would be required to correct this situation. Both the peak density encountered over the orbit, as well as the average density are depicted on the vertical axis, assuming the solar flux and geomagnetic characteristics listed.

SPACE STATION PITCH TEA vs DENSITY

ALTITUDES DEFINED BY F10.7=230, AP=140



PITCH T.E.A. (DEGREES FROM LVLH)

■ AVER. ORBIT DENSITY

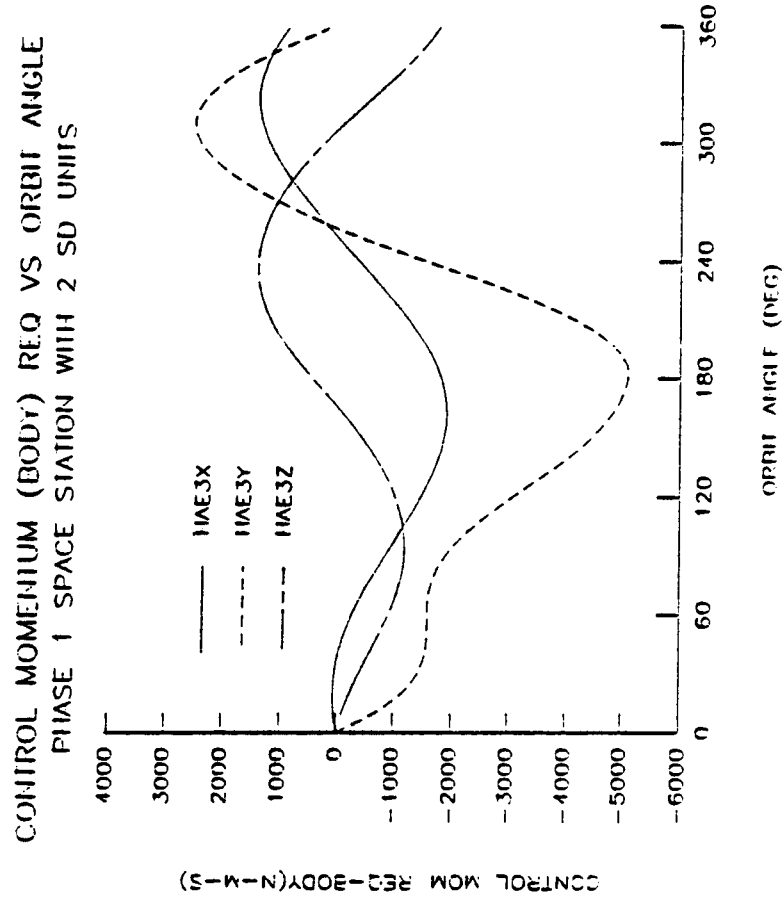
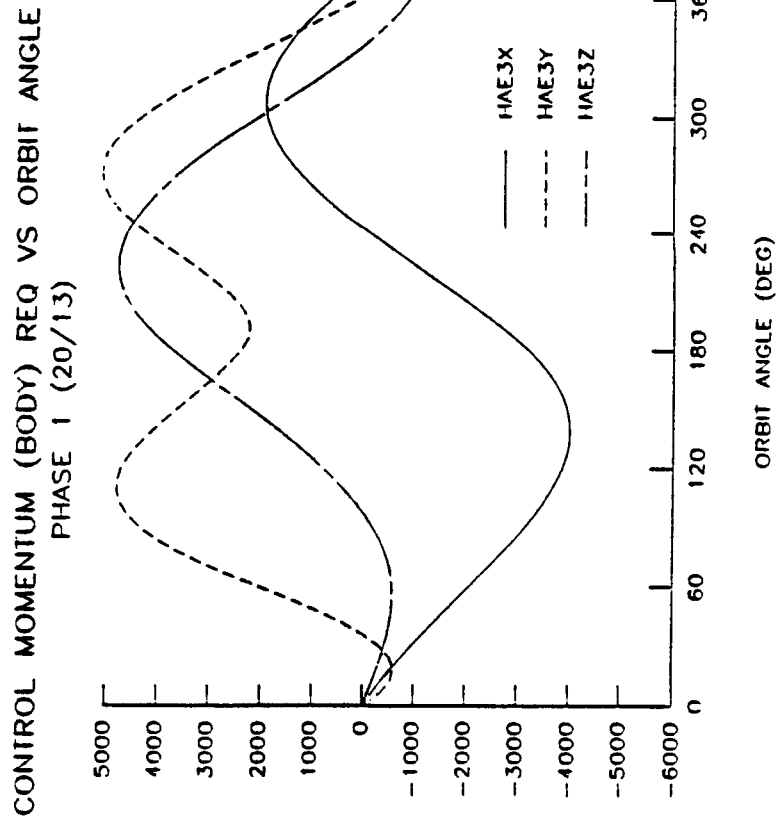
+ PEAK ORBIT DENSITY

ARTICULAR PV/SD CONTROL MOMENTUM COMPARISON

As previously mentioned, CMGs are used as primary angular momentum control devices for the purpose of providing attitude stability. As can be seen, a comparison of the all-photovoltaic option to a hybrid configuration which contains two 25 kW solar dynamic units and two 18.75 kW photovoltaic units results in nearly equal attitude control momentum requirements and pitch TEA's. The solar dynamic option has a slightly smaller pitch TEA due to the reduced effective aerodynamic area, resulting in a smaller aero induced torque. Note that the two configurations compared are both relatively symmetric about the plane perpendicular to the truss. The peak momentum requirements are on the order of 5000 N-M-S.

ARTICULAR PV/SD CONTROL MOMENTUM COMPARISON

- 2 SD/PV UNIT CONFIGURATION COMPARED TO ALL PV BASELINE
 - 2 25 KW SD UNITS & 2 18.75 KW PV UNITS
- CONTROL MOMENTUM REQUIREMENTS SIMILAR
 - 9 DEG. TEA FOR ALL PV CONFIGURATION
 - 8 DEG. TEA FOR 2 SD/PV CONFIGURATION

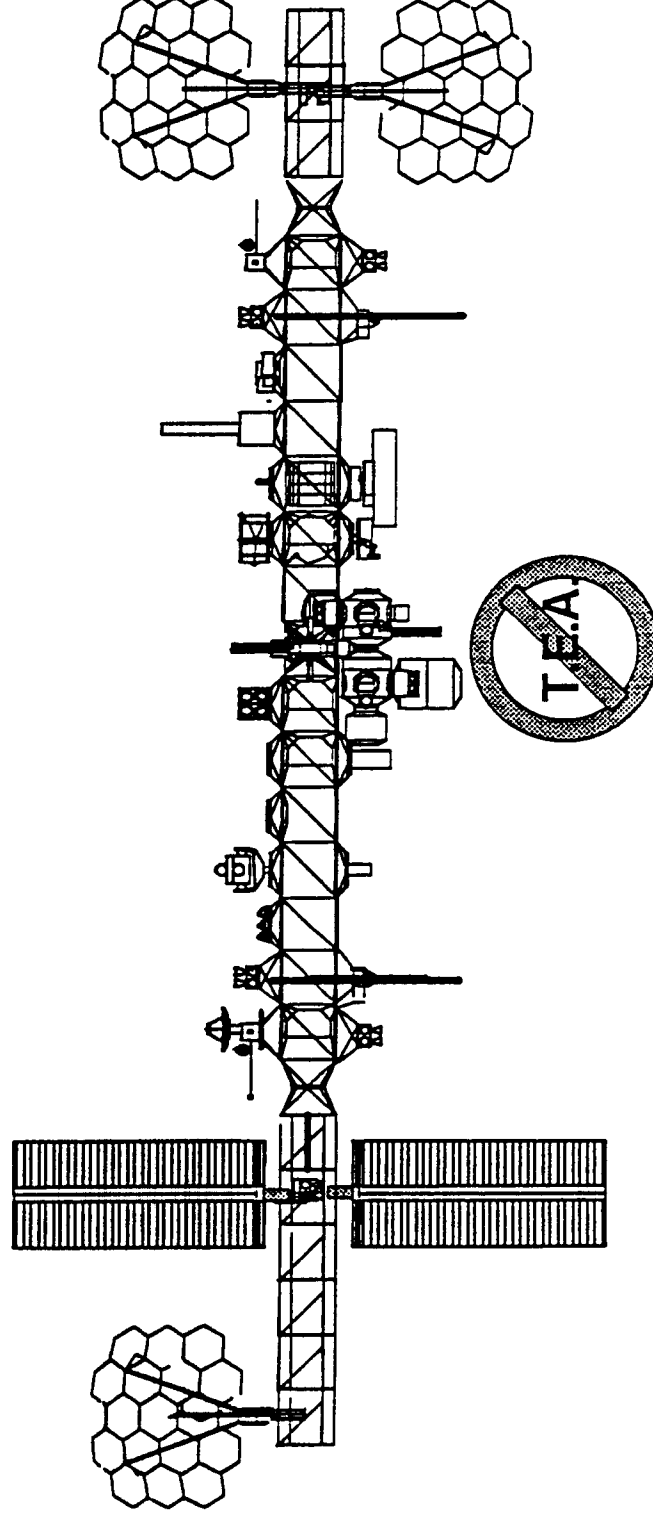


ARTICULATING 3 SD / 1 PV CONFIGURATION

The 3 solar dynamic unit configuration illustrated is asymmetric about the yaw axis of the space station. The resulting CP – CG offset along the Y-axis results in a large aerodynamically induced yaw torque, as well as a continuously changing mass imbalance due to part articulation. This geometry yields no torque equilibrium attitude with reasonable control momentum requirements. Potentially, an active attitude control law using momentum feedback could be utilized to maneuver the vehicle over an orbit to prevent CMG saturation, adversely impacting the microgravity and payload pointing environment.

ARTICULATING 3 SD / 1 PV CONFIGURATION

- Area Asymmetry Yields Large Yaw Torques
- Very Sensitive To Articular Mass Imbalance
- Unreasonable Angular Momentum Control Solutions

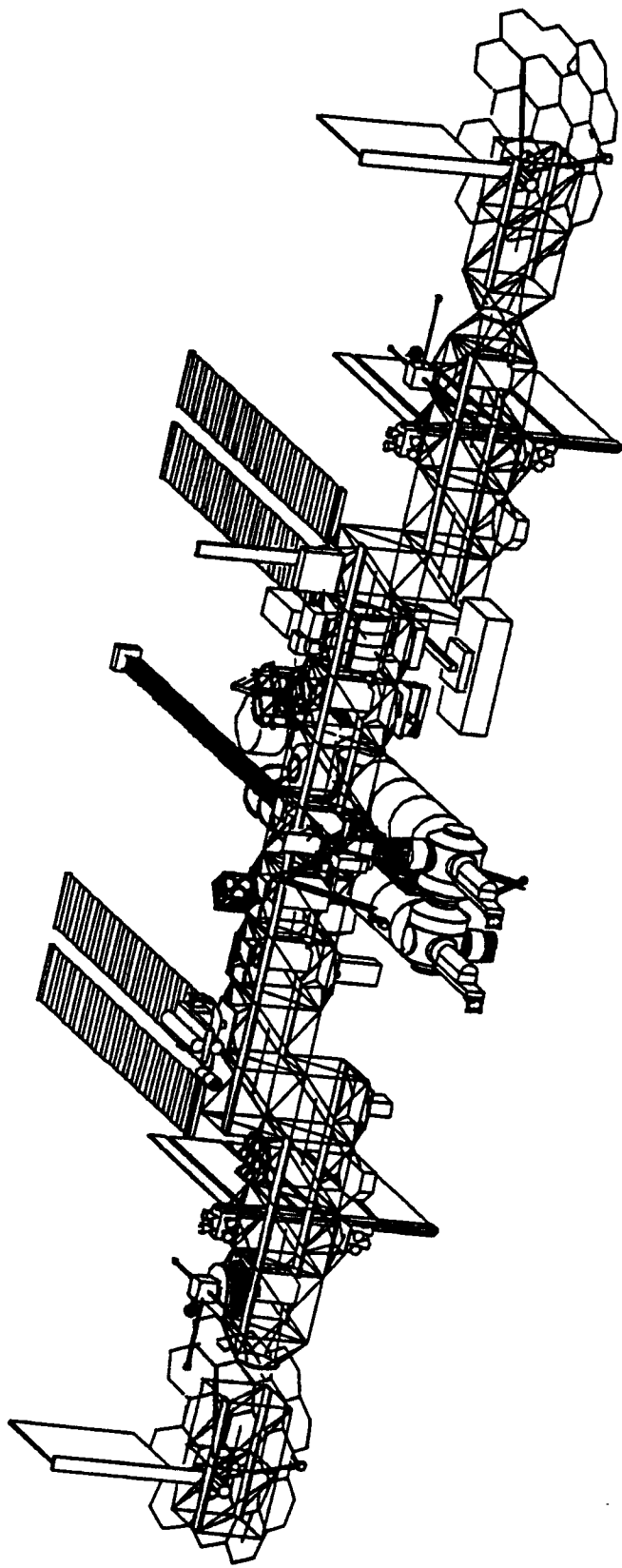


TWO SOLAR DYNAMIC UNIT CONFIGURATION

With the exception of the generic instability issue which requires active attitude control, effects of the other problems discussed thus far, namely, the yaw axis CP-CG offset which led to a pitch TEA, and the asymmetric 3 SD configuration which yielded no reasonable TEA, can be reduced by the configuration shown below. The key attributes include two symmetric solar dynamic units, two symmetric trailing photovoltaic arrays, and an offset truss structure. The offset truss configuration has been extensively studied and documented for application in Space station Freedom configuration considerations¹

1. "Impact of Asymmetric Physical Properties on Large Space Structures", DeRyder,L, Troutman,P, and Heck,M; AIAA SDM Issues of International Space Station Conference, Williamsburg, Va, April, 1988 Paper no. 88-2490.

TWO SOLAR DYNAMIC UNIT CONFIGURATION



LaRC SE&I



OFFSET TRUSS, TWO SOLAR DYNAMIC UNITS

In this configuration, the solar dynamic units are sized such that two can provide the power requirements. In addition, two trailing photovoltaic arrays are designed *inboard* of the alpha joint. The arrays provide supplemental power, and have the capability to beta track the sun (to minimize power losses). The arrays are always feathered with respect to the velocity vector in order to minimize drag and thus aerodynamic forces (which adversely impact station orbit decay rate), and aerodynamic torques (which give rise to attitude control requirements and non-local vertical TEAs).

The introduction of an offset truss minimizes the CP-CG offset along the z-axis, thus reducing pitch TEA angles. Compared to the asymmetric 3 solar dynamic unit configuration, attitude control requirements are significantly reduced. The assembly of the single jointed arrays inboard of the alpha joints simplifies the assembly sequence.

The two unit configuration still has significant changes in mass properties due primarily to articulation of the solar dynamic power units outboard of the alpha joint.

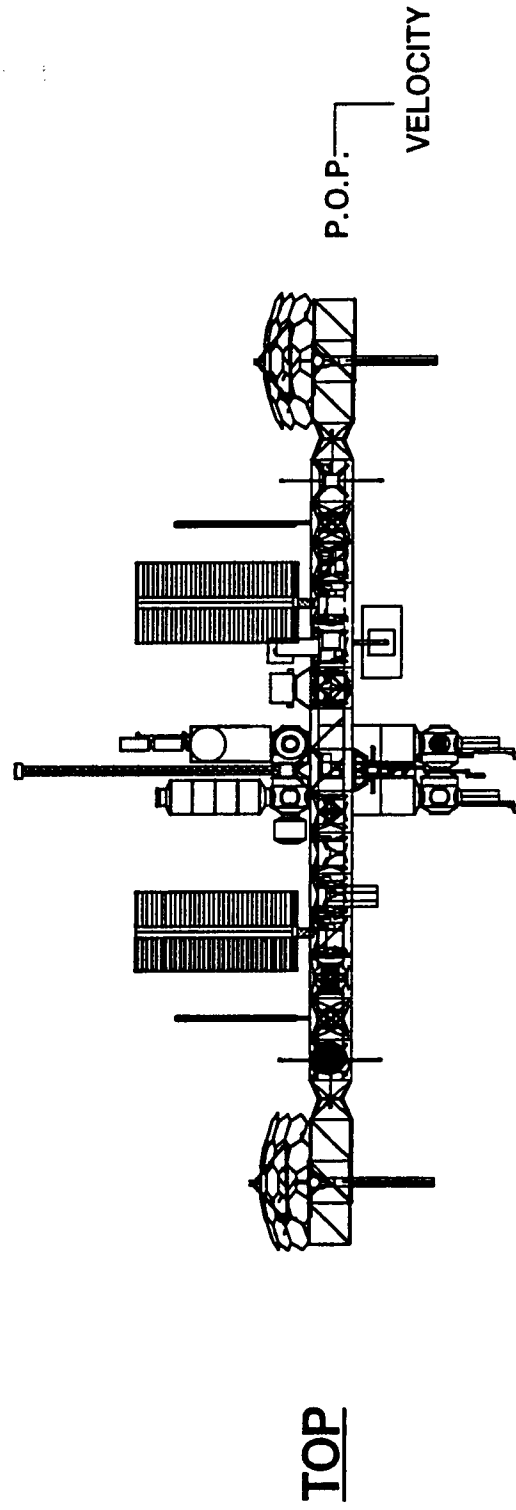
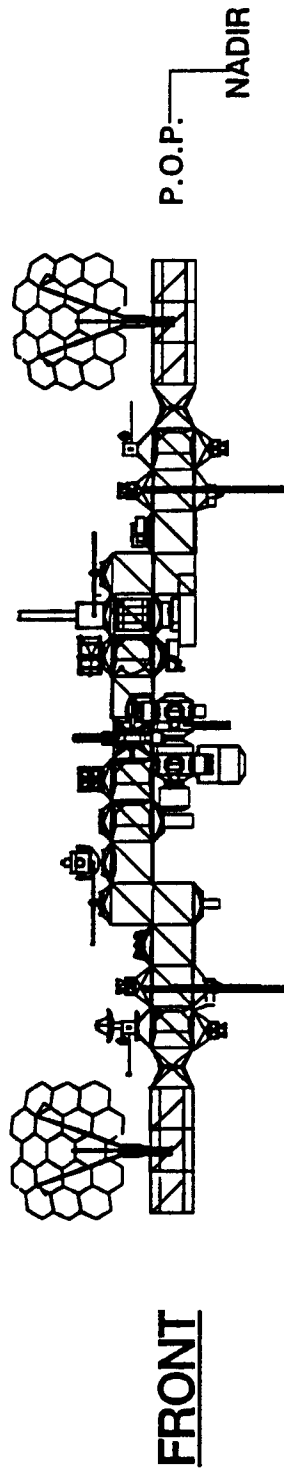
OFFSET TRUSS, TWO SOLAR DYNAMIC UNITS

CONFIGURATION MODIFICATIONS:

- REPLACE ARTICULATING PV ARRAYS WITH TRAILING FEATHERED ARRAYS.
- SIZE SD UNITS SO THAT ONLY TWO ARE REQUIRED.
- USE OFFSET TRUSS TO REDUCE CP/CG OFFSET.

IMPROVEMENTS RESULTING FROM CONFIGURATION MODIFICATIONS:

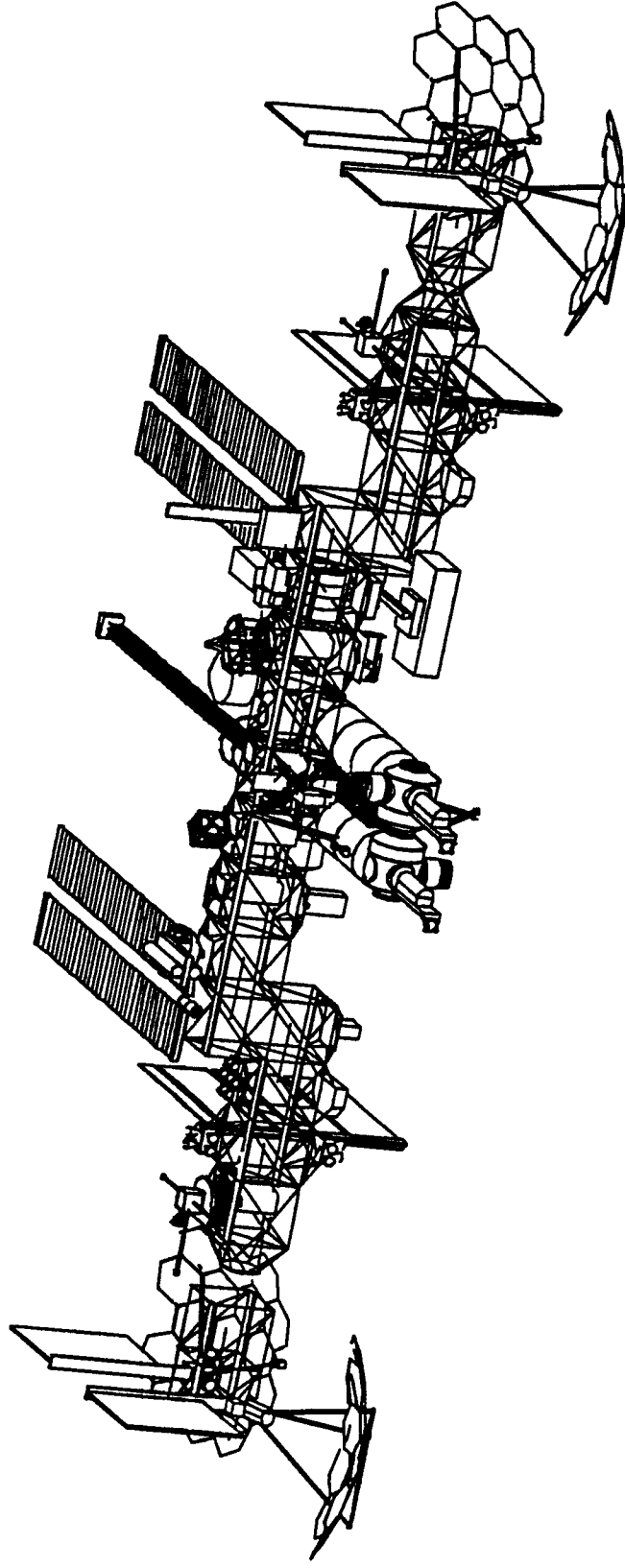
- SIMPLIFIED ASSEMBLY SEQUENCE.
- REDUCED MOMENTUM CONTROL DYNAMICS.
- REDUCED PITCH T.E.A.



FOUR SOLAR DYNAMIC UNIT CONFIGURATION

Another more symmetrically area and mass balanced space station configuration shown here has four solar dynamic units appropriately sized to provide the required power. It is otherwise similar to the two unit configuration previously discussed, with two trailing photovoltaic arrays, and and offset truss.

FOUR SOLAR DYNAMIC UNIT CONFIGURATION



LaRC SE&I



OFFSET TRUSS, FOUR SOLAR DYNAMIC UNITS

In this configuration, the solar dynamic units are sized such that four can provide the power requirements. In addition, two trailing photovoltaic arrays are designed *inboard* of the alpha joint. The arrays provide supplemental power, and have the capability to beta track the sun (to minimize power losses). The arrays are always feathered with respect to the velocity vector in order to minimize drag and thus aerodynamic forces (which adversely impact station orbit decay rate), and aerodynamic torques (which give rise to attitude control requirements and non-local vertical TEAs).

The introduction of an offset truss minimizes the CP-CG offset along the z-axis, thus reducing pitch TEA angles. Compared to the asymmetric 3 solar dynamic unit configuration, attitude control requirements are significantly reduced. The assembly of the single jointed arrays inboard of the alpha joints simplifies the assembly sequence.

The four unit configuration is more nearly symmetric above and below the truss, thus reducing mass property changes which take place during articulation as compared to the two solar dynamic dish configuration.

OFFSET TRUSS, FOUR SOLAR DYNAMIC UNITS

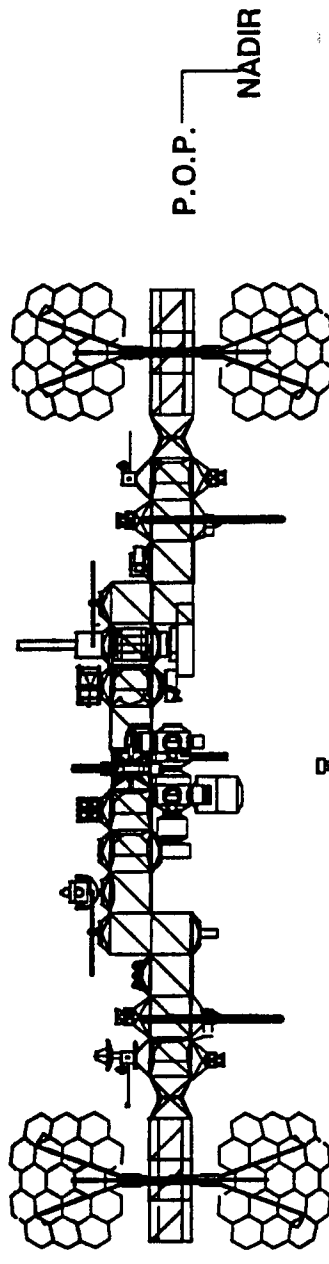
CONFIGURATION MODIFICATIONS:

- REPLACE ARTICULAR PV ARRAYS WITH TRAILING FEATHERED ARRAYS.
- SIZE SD UNITS SO THAT FOUR ARE REQUIRED.
- USE OFFSET TRUSS TO REDUCE CP/CG OFFSET.

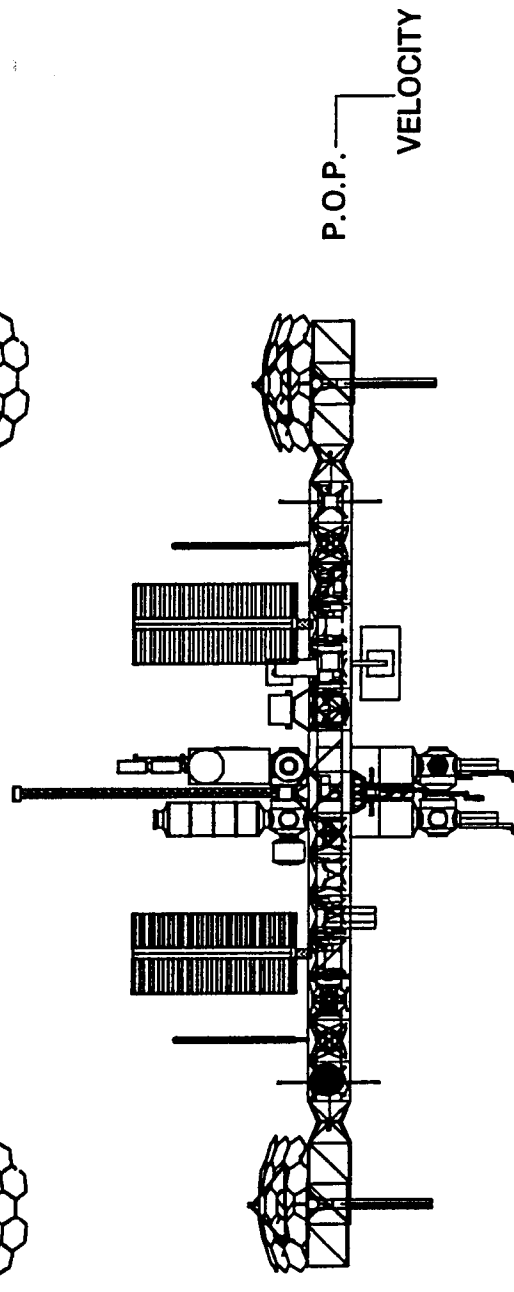
IMPROVEMENTS RESULTING FROM CONFIGURATION MODIFICATIONS:

- SIMPLIFIED ASSEMBLY SEQUENCE.
- REDUCED MOMENTUM REQUIREMENTS AND CONTROL DYNAMICS.
- REDUCED PITCH T.E.A.
- REDUCTION OF CG AND ATTITUDE DEVIATIONS.

FRONT



TOP



SPACE STATION FLIGHT MODE CHARACTERISTICS

The tabular summary compares results among the baseline Phase1 (20/13 assembly flight scenario) which has photovoltaic arrays only, a modified Phase 1 where two arrays are replaced by two solar dynamic units, the three solar dynamic unit configuration, and two configurations with offset truss and trailing array pairs : one with two solar dynamic units, the last with four solar dynamic units. Results include the torque equilibrium attitude, the peak angular momentum control requirement, and the secular angular momentum control requirement.

Simply replacing two of the photovoltaic arrays with solar dynamic units on the Phase 1 configuration does not significantly impact the TEA or the control momentum requirements.

As discussed earlier, the mass and area asymmetric three solar dynamic unit configuration does not yield a reasonable TEA. Evidently, such extreme asymmetry adversely impacts attitude flight control, and should be avoided if possible. Further studies would be required to determine if an active control law could be designed to maintain attitude if such a configuration were baselined.

The offset truss configurations with trailing, feathered solar arrays significantly reduces the pitch TEA, allowing the station to fly in a more nearly local vertical orientation. The two SD version has a sizable pitch aero torque which results in similar peak momentum requirements when compared to the Phase 1 results listed. The four SD configuration, however, with solar dynamic units on both sides of the truss, result in smaller aerodynamically induced pitch torques and hence, smaller peak angular momentum requirements. For a solar dynamic powered station, the 4 SD unit configuration, coupled with the offset truss and trailing photovoltaic arrays, appear to offer the best geometry from a flight attitude control point of view.

SPACE STATION FLIGHT MODE CHARACTERISTICS

	TEA * (Yaw, Pitch, Roll) (DEG)	Peak * Angular Momentum (Nms)	Secular * Angular Momentum RSS (Nms)	COMMENTS
PHASE 1 (20/13)	(0.5, -9.0, -0.3)	5100	1100	PV Array Area Dominant
PHASE1 WITH 2 SD UNITS	(0.6, -8.0, -0.1)	5100	2000	Articular Dynamic Aero Imbalance
1 PV UNIT, 3 SD UNITS	N/A	N/A	N/A	Articular Mass & Area Imbalance
OFFSET TRUSS, 2 SD UNITS, TRAILING ARRAYS,	(1.1, -3.1, -1.2)	5800	1700	Reduced CP-CG Offset
OFFSET TRUSS, 4 SD UNITS, TRAILING ARRAYS	(1.1, -3.0, -0.8)	2700	1300	Reduced CP-CG Offset, Balanced Aero

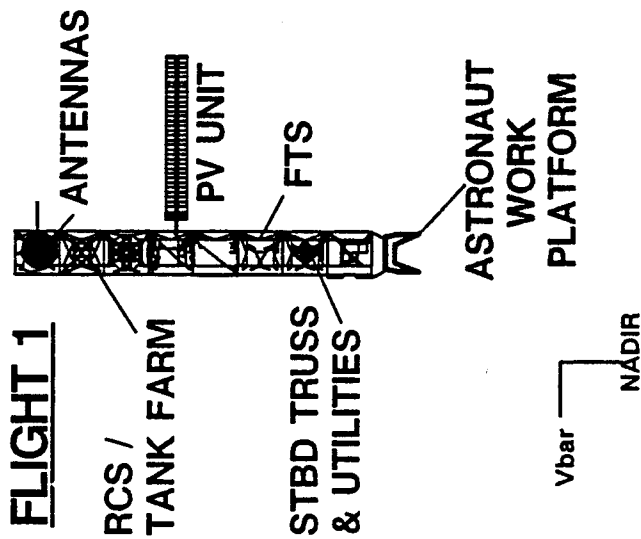
* 220 Nmi, F10.7=230, AP=140 Atmosphere

ASSEMBLY SEQUENCE USING SD UNITS

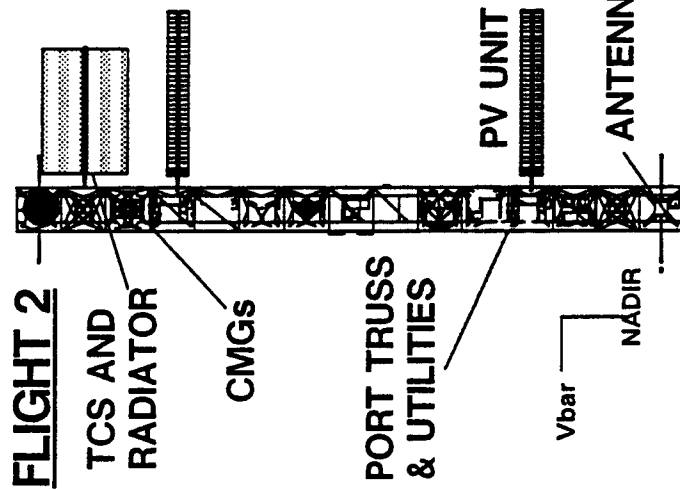
Locating feathered PV arrays inboard the alpha joint simplifies the assembly sequence and provides additional options. The first flight places in orbit the starboard inboard eight bays of truss, a tank farm, RCS thrusters, the flight telerobotics system (FTS), and the avionics pallet. The flight 1 orientation is a three axis gravity gradient stable attitude with full reboost capability and one feathered PV unit for power. The second flight manifests the port half of the transverse boom along with the CMG's, some thermal radiators and another feathered PV unit. The third flight transports a node, MSC and a docking adapter and utilizes the same gravity gradient stable flight mode. Flight 4 elements consist of two solar dynamic units that are assembled if EVA times are within acceptable limits. If only one SD unit can be assembled, the configuration remains in the gravity gradient flight mode with the other SD unit stowed on the transverse boom. If there is time to assemble both units, then the configuration will fly in its nominal LVLH flight mode. Flight 5 deploys the U.S. Lab and the second SD unit is assembled if required. The remainder of the assembly sequence is similar to the baseline 20/13 sequence.

ASSEMBLY SEQUENCE USING SD UNITS

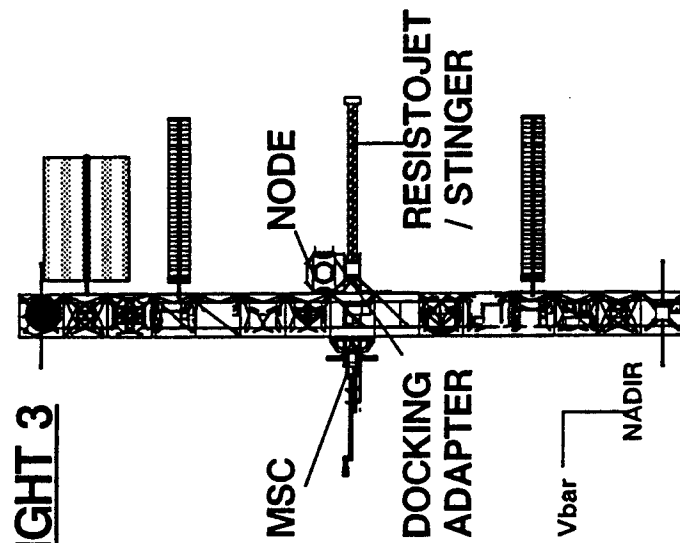
FLIGHT 1



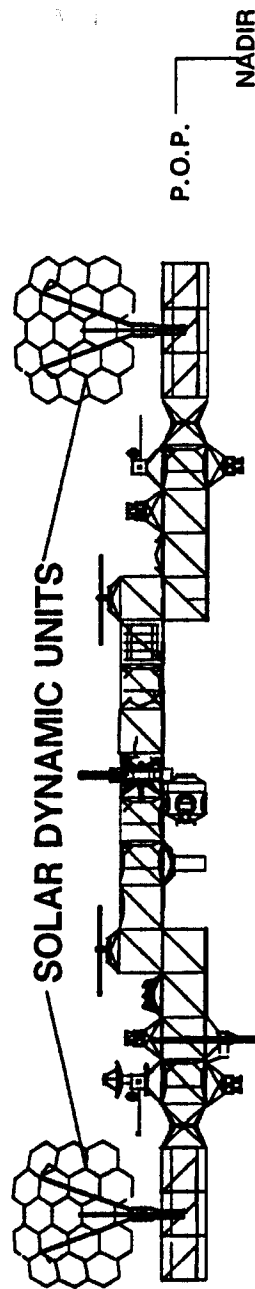
FLIGHT 2



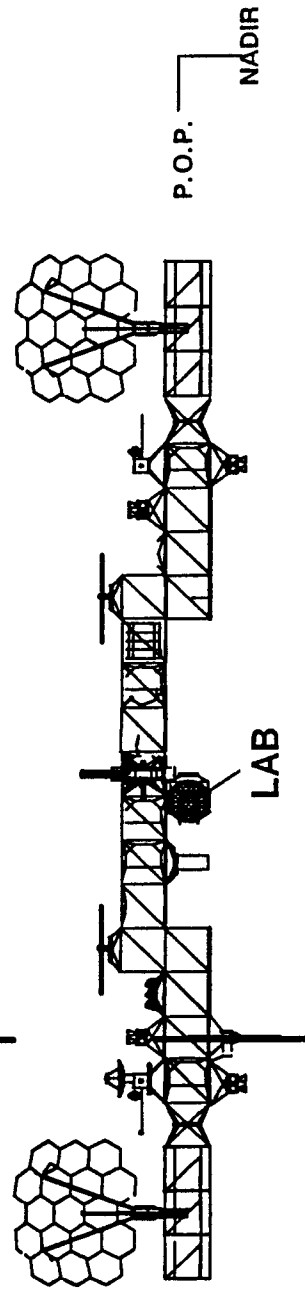
FLIGHT 3



FLIGHT 4



FLIGHT 5



20 / 13 SOLAR DYNAMIC POWER ASSEMBLY SEQUENCE

The table shows a *potential* assembly sequence for the 4 solar dynamic unit configuration previously discussed. Note that the baselined twenty flight assembly sequence with a permanently manned configuration after 13 flights is preserved. The table lists which components are brought up on each flight. The assembly sequence assumes the baselined Orbiter cg envelope (which is currently under review). The amount of EVA time required to support solar dynamic unit assembly must be studied further.

20 / 13 SOLAR DYNAMIC POWER ASSEMBLY SEQUENCE

1	FEL	MB-1	STBD PV MODULE, STBD TRUSS (9 BAYS), AVIONS PALLET, ANTENNA PALLET, TANK FARM #3, RCS MODULES (3), AWP W/MOBILE TRANSPORTER, FTS
2		MB-2	PORT PV MODULE STBD TRUSS (8 BAYS), STBD TCS SYSTEM, CMG PALLET, PMAD PALLET, TDRSS ANTENNA, RCS MODULE, PORT ANTENNA PALLET, UNPRESS. LOG. BERTHING MECH.
3		MB-3	AFT STBD NODE, MODULE SUPPORT STRUCT, MSC PHASE 1, PRESS.DOCKING MODULE, FMAD PALLET, STINGER/RESISTOJET
4		MB-4	PORT + STBD SD UNITS, ALPHA JOINTS
5	EMTC	MB-5	U. S. LAB MODULE
6		MB-6	AIRLOCK (QUAL. SSEMU), PORT TCS SYSTEM, TANK FARM #4, CUPOLA, TANK FARMS #2 & #3
7		OF-1	PRESS. LOG. MOD. MODULE OUTFITTING
8		UOF-1	EXTENDED DURATION ORBITER (EDO), ATTACHED PAYLOADS & EQUIP
9		MB-7	AFT PORT NODE, AIRLOCK (SSEMU), PRESS. DOCKING MODULE, ATTACHED PAYLOAD & EQUIP
10		MB-8	U. S. HAB MODULE
11		MB-9	PORT & STBD FORWARD NODES, CUPOLA, MODULE OUTFITTING.
12		OF-2	PRESS. LOG. MOD. MODULE OUTFITTING. SPDM, 2ND TRUSS UTILITIES
13	PMC	MB-10	CREW (4), PRESS. LOG. MOD., UNPRESS. LOG. CARRIER, LOGISTICS
14		MB-11	PORT & STBD OUTBOARD SD MODULES (37.5 KW)
15		MB-12	SSRMS-2, MMD PHASE 1, ATTACH. PAYLOADS & EWUP., LOGISTIC SPARES
16		L-1	PRESS. LOG. MOD., UNPRESS. LOG. CARRIER, LOGISTICS
17		MB-13	JEM MODULE, JEM EXPOSED FACILITY #1, LOGISTIC SPARES
18		MB-14	ESA MODULE, LOGISTIC SPARES
19		L-2	PRESS. LOG. MOD., UNPRESS. LOG. CARRIER, LOGISTICS
20	AC	MB-15	JEM EXPOSED FACILITY #2, JEM ELM, INT'L EQUIP & PAYLOADS, LOGISTICS SPARES

SUMMARY

This report examines the issues related to utilizing a solar dynamic power system to replace a photovoltaic power system to provide electrical energy for Space Station Freedom.

It was determined that the use of feathered photovoltaic arrays located inboard of the alpha joints could provide ancillary or contingency power while 1) simplifying the overall assembly process, 2) shortening the utility run, and 3) reducing the effective aerodynamic area, and hence, the aero induced orbit decay rates and torques (independent of array blanket area size).

The decision to use two or four solar dynamic units can be based on a power phasing decision. Either appears to support maintaining a 20/13 assembly sequence. The three unit option, however, exhibits undesirable flight attitude control characteristics.

The use of an offset truss configuration is seen to provide significant reduction of the pitch TEA by minimizing the CP-CG offset along the z-axis.

In summary, alternate Space Station Freedom configurations have been examined and shown to accommodate the use of solar dynamic power.

SUMMARY

- **CONFIGURATION MODIFICATION CONSIDERATIONS FOR SD POWER UNITS**
 - **OFFSET TRUSS TO MINIMIZE CG / CP DISPLACEMENT**
 - **MINIMUM SENSITIVITY TO ARTICULAR DYNAMIC ASYMMETRY / IMBALANCE**
 - **FEATHERED PV ARRAYS FOR ANCILLARY / CONTINGENCY POWER**
 - **SIMPLER ASSEMBLY INSIDE ALPHA JOINT**
 - **CLOSER TO NODE, SHORTER UTILITY RUN**
 - **LESS SENSITIVE TO SOLAR POINTING LOSS (SMALL TEA / ATTITUDE VARIATIONS)**
 - **FLIGHT DYNAMICS INSENSITIVE TO PV POWER LEVEL / BLANKET AREA DECISIONS**
 - **2 / 4 SD UNIT CAN BE A POWER PHASING DECISION**
 - **SIZE TO MAINTAIN 20 / 13 ASSEMBLY SEQUENCE**



Report Documentation Page

1. Report No. NASA TM-101603	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Alternate Space Station Freedom Configuration Considerations to Accommodate Solar Dynamic Power		5. Report Date May 1989	
		6. Performing Organization Code	
7. Author(s) L. J. DeRyder, J. N. Cruz, M. L. Heck, B. P. Robertson, and P. A. Troutman		8. Performing Organization Report No.	
		10. Work Unit No. 476-50-02-02	
9. Performing Organization Name and Address NASA Langley Research Center Hampton, Virginia 23665-5225		11. Contract or Grant No.	
		13. Type of Report and Period Covered Technical Memorandum	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546-0001		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract <p>The results of a technical audit of the Space Station Freedom Program conducted by the Program Director was announced in early 1989 and included a proposal to use solar dynamic power generation systems to provide primary electrical energy for orbital flight operations rather than photovoltaic solar array systems. To generate the current program baseline power of 75 kw, two or more solar concentrators approximately 50 feet in diameter would be required to replace four pairs of solar arrays whose rectangular blanket size is approximately 200 feet by 30 feet. The photovoltaic power system concept uses solar arrays to generate electricity that is stored in nickel-hydrogen batteries. The proposed concept uses the solar concentrator dishes to reflect and focus the Sun's energy to heat helium-xenon gas to drive electricity generating turbines. Circulation of the gas through eutectic LiF-CaF₂ salt beds stores thermal energy to operate the turbines when the station's orbital trajectory is occulted from the sunlight. In addition to an overall increase in solar to electric energy conversion efficiency, the primary advantage of the solar dynamic power system concept over the photovoltaic power system concept is the reduced life cycle cost of blanket cell maintenance and battery replacement. A second key advantage is reduced aerodynamic drag area which is a major flight dynamic control system driver.</p> <p>The purpose of this report is to consider the station configuration issues for incorporation of solar dynamic power system components. Key flight dynamic configuration geometry issues are addressed and an assembly sequence scenario is developed.</p>			
17. Key Words (Suggested by Author(s)) Space Station Freedom Solar Dynamic Power System Studies		18. Distribution Statement Unclassified - Unlimited Subject Category 18	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 34	22. Price A03